

Leonardo da Vinci

A NOTE ON THE RELATION BETWEEN HIS SCIENCE AND HIS ART

By KENNETH CLARK

IT IS USUAL TO TREAT LEONARDO as a scientist and Leonardo as a painter in separate studies. And no doubt the difficulties in following his mechanical and scientific investigations make this a prudent course. Nevertheless, it is not completely satisfactory, because in the end the history of art cannot be properly understood without some reference to the history of science. In both we are studying the symbols by which man affirms his mental scheme, and these symbols, be they pictorial or mathematical, a fable or a formula, will reflect the same changes. They are very little influenced by accidents. Discoveries may appear to be accidental, but in fact each epoch gets the discoveries it needs. Aristarchus discovered that the earth moves round the sun, but the idea lay dormant till Copernicus; Poggio found the works of Tacitus in the Medici library, read them and put them quietly back on the shelves. They would have destroyed the humanist's mental picture of Antiquity. If the Laocoön had been unearthed 200 years earlier we may be certain that it would have been buried again. So with Leonardo, the discoveries and anticipations which he made in the art of painting, some of which could not be

absorbed till a far later date and some of which are becoming comprehensible only now, must be looked at in relation to what our ancestors would have called his natural philosophy. One cannot be understood without the other.

We must admit, however, that whereas the study of Leonardo's art is, for the most part, exhilarating and enthralling, the study of Leonardo's thought is disheartening and difficult. There are three reasons for this which anyone who intends to read Leonardo's writings may be glad to have set down. The first is that his manuscripts are not, as was once supposed, made up chiefly of original observations, but are to a very large extent commonplace books in which he copied down what he had read. Even Richter, from whose admirable volumes¹ Leonardo's writings are chiefly known, did not (or would not) recognize this, and actually says that he was not a great reader. An instance of this wilful disregard of Leonardo's sources is still to be found in the new edition of Richter's *Literary Works*. Leonardo had written "Cosa mortal passa e non dura," which is a line from Petrarch. The

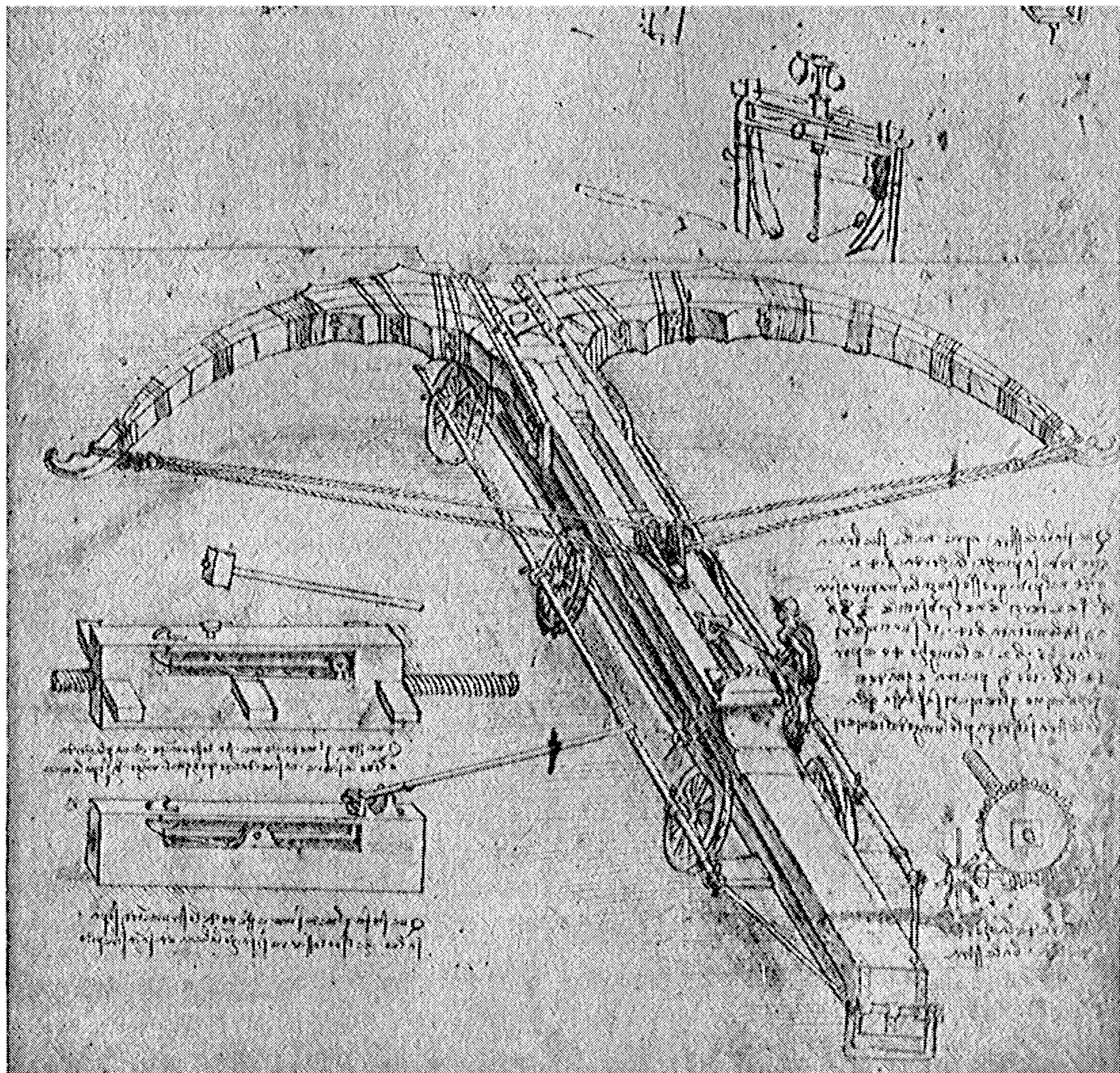
¹ J. P. Richter, *The Literary Works of Leonardo da Vinci*, Oxford 1939 (originally published 1883)

reading is clear and unmistakable. Richter transcribed it "Cosa mortal passa e non *d'arte*," which, although neither an original thought nor an idiomatic Italian sentence, was actually taken by the Vincian society as its motto. The degree to which Leonardo's MSS. are made up of quotations was first made clear by a scholar named Solmi, who published in his *Fonti dei Manoscritti di Leonardo da Vinci* several hundred of his sources. Since then a great many more have been identified. Now, there is nothing dishonourable in this discovery. In 1480 most of the writings which Leonardo would wish to read existed only in manuscript; and even those which had been printed were often hard to come by. It was usual, in the *quattrocento*, for scholars to make copies of whole books which interested them, and the habit of compiling vast commonplace books of information lasted up to the eighteenth century. The notebooks of John Evelyn in Christ Church library are one example among many. But of course this discovery does make the study of Leonardo's thought very much more difficult, because unless we have a complete grasp of the state of knowledge, and the sources of knowledge, in the Renaissance, we can never be certain when Leonardo is making an original observation. The same is true of technology. Of the hundreds of machines scattered through Leonardo's notebooks, which are inventions, and which are simply drawings of things seen? Here I am afraid we must resign ourselves to never knowing the truth. Nothing is more baffling than the history of technology, partly because before the age of patent law, every guild and every city tried to keep its mechanical devices a secret, and partly because people do not preserve out-of-date machinery. It happens that Leonardo was almost the first man to draw machinery who was a great enough artist for his drawings to be preserved.² Personally I believe that most of these drawings are based on existing machines, but that Leonardo liked to extend and elaborate them, often beyond the technical resources of the day. I think it doubtful if he discovered

² The drawings of machines in the MSS. of Francesco di Giorgio may be a year or two earlier than Leonardo's earliest, i.e., before 1480. Leonardo owned one such MS. by Francesco di Giorgio and annotated it, but at a later date.

any new mechanical principles. But even if this is an overstatement, it remains almost impossible to say how many of the "inventions" in Leonardo's notebooks can in any sense be called his own.

This would not be important if he had put other people's ideas in a new and significant order, but (and this is our second difficulty) the disorder of the notebooks is absolute. This disorder is partly due to the fact that Leonardo lived at an interlunar period in the history of thought. The logical system of scholasticism, which compelled all facts into the service of God, had broken down under the weight of its own elaboration. The new rationalism of the seventeenth century, with its faith in the laws of nature, had yet to be evolved. Leonardo hated generalizations because he saw them as leading directly to the kind of metaphysical speculations which, at that date, had lost their value for the human spirit. "It is true," he says, "that impatience, the mother of stupidity, praises brevity, as if such persons would not need a lifetime to acquire a complete knowledge of one single subject, such as the human body; and yet they want to comprehend the mind of God in which the universe is included, weighing it minutely and mincing it into infinite parts, as if they had to dissect it." This is a remarkable anticipation of the scientific attitude, and, in consequence, some writers on Leonardo have referred to the disorder of the notebooks as if it had some positive value. Any order, they say, would have implied some pre-conceived idea, prejudicial to the purity of the facts. M. Valéry's famous introduction to the Method of Leonardo is based on a slightly more subtle version of the same argument: he says that Leonardo's sense of order was so all-embracing that the facts were equally valid however they were related to one another. "*Il a un sens extraordinaire de la symétrie qui lui fait problème de tout.*" There is a grain of truth in this; but by itself, as an explanation of Leonardo's disorderliness, it will not do. We cannot say of the painter of the *Last Supper* that he lacked the synthetic faculty; but the fact remains that he had a real aversion from arranging his observations. He says more than once that he has not done so for lack of time, but this is unconvincing, because he will



From the Codice Atlantico, Ambrosian Library, Milan

Great Crossbow

record the same observations and proofs, in almost identical language, dozens of times. Clearly, this gave him great satisfaction ; and it helped to put off the evil day when he should have to do something with the mass of material he had collected. There must be many researchers in our Universities who sympathize with him.

The third cause of bewilderment in Leonardo's manuscripts is one which scholars brought up in the rational-scientific traditions of the last century almost always shirked ; one which would, indeed, have invalidated their

whole picture of him : Leonardo's mind passed without warning, and almost without consciousness, from fact to fantasy, from experience to imagination. A symptom of this is the impracticability which remains one of the most paradoxical things about him. The most scientifically minded artists of the Renaissance painted his two great wall paintings with so little science that they almost immediately disintegrated. The inventor of elaborate machinery had so little technical skill that he was unable to cast in bronze the horse for the Sforza monument, and the Duke had to send

to Florence for one or two masters more apt for the work. We have no record of how Leonardo's bombards and ballistas, tanks and battering rams, to which he attached such importance, stood the test of war. It is true that he was employed by that eminently practical man (in small things) Cesare Borgia. But then his powers of persuasion were irresistible. After his return to Florence in 1503 he persuaded the Florentine Government—probably the most hard-headed body in Europe—to accept his design for diverting the Arno so that it should no longer enter the sea by Pisa, but in Florentine territory. Some of his maps for this still survive, and some drawings of men digging, but no trace of the canals ; and in fact his scheme was wholly beyond the technical powers of the time. It is typical of Leonardo's mind that his notes on the subject are, up to a point, quite factual ; but that when he comes to the real difficulty, a range of hills, he says simply, "At Serravalle I shall cut through" ; without the slightest indication how.

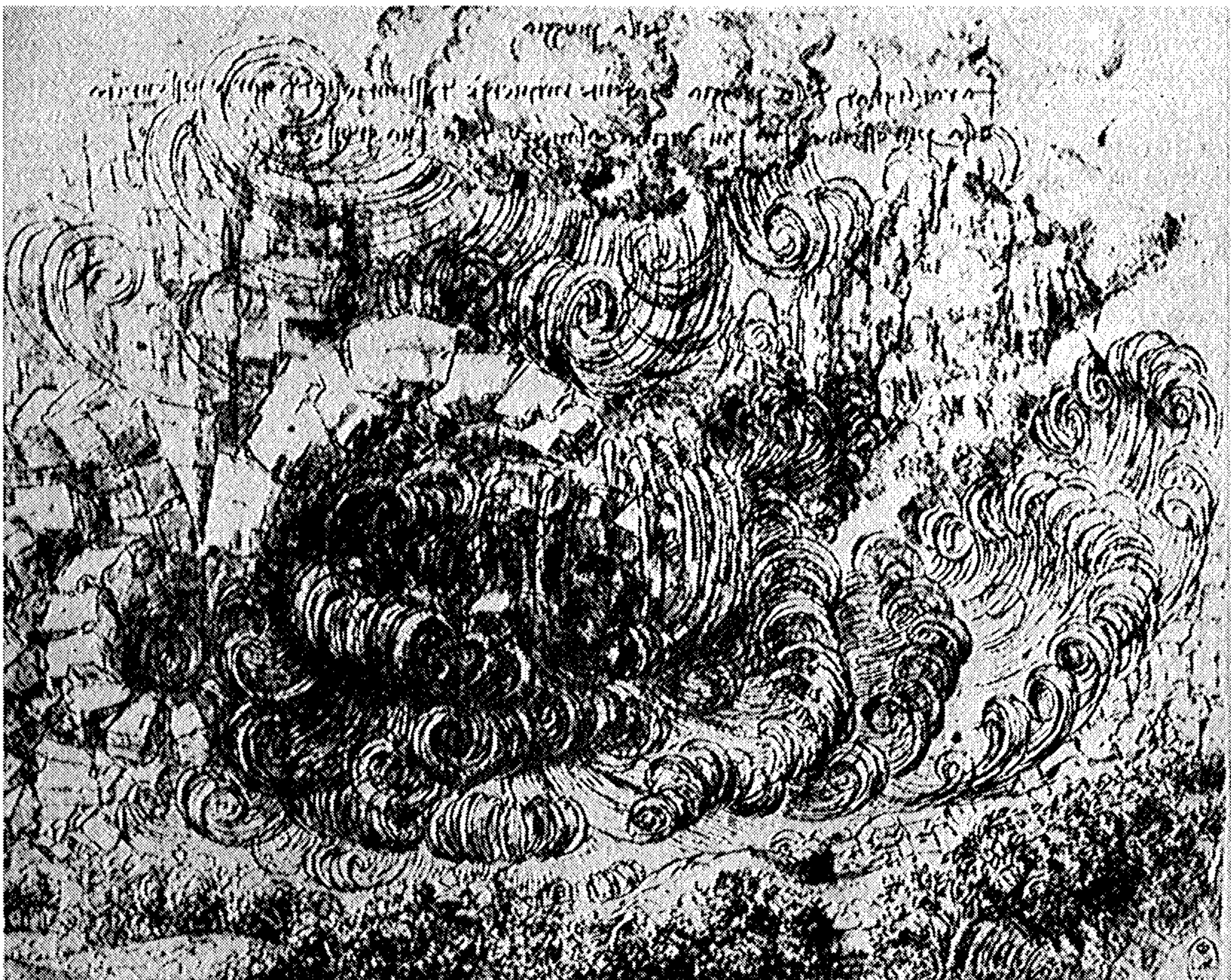
Now, although Leonardo scholars have not really faced the implications of these sudden swervings into fantasy, they have not been able to ignore them altogether, as they play a great part in his notebooks, both in his writings and in his illustrative drawings. I may illustrate this by one small symbolic example. Leonardo was fond of drawing artesian screws and other spiral devices. On a sheet of doodles in the *Codice Atlantico* he has drawn such a spiral for its own sake, and he has endowed it with a kind of monstrous life, so that it changes, like Aaron's rod, into a serpent. And above it he has written "Body born of the power of projection of Leonardo Vinci, disciple of experience."³

This interweaving of fact and fantasy in Leonardo's mind is partly due to a medieval element which is frequently perceptible in his paintings ; and students of the middle ages have grown accustomed to the way in which

³ *Corpo nato della prospettiva / di leonardo vinci dissiepolo de / la sperientia.* The word *prospettiva*, as used in the Renaissance, cannot be rendered in English by the word perspective. The *Codice Atlantico* is the name given to a huge scrap-book of his notes and drawings in the Ambrosian Library, Milan.

the most powerful intellects accepted as evidence in a rational scheme fantasies which would not deceive a modern child. But Leonardo was not only the heir of a myth-accepting system of thought ; he was an imaginative artist, haunted by certain visions which his inward eye had rendered as real to him as any observation. If he passes freely from reason to imagination, he passes as freely back from imagination to reason. This is the origin of his famous advice to a painter to study "stains on walls or the embers of a fire wherein he may find divine landscapes, battles, figures in violent action or even the expressions of faces. These the painter will be able to reduce to their proper form" ; and Leonardo adds, "be sure you know the structure of all that you then wish to depict."

I quote this familiar passage, because it leads to the first clue I can offer to anyone attempting the study of the notebooks. They are the work of a great artist. Leonardo's interest in science grew so intense that we forget that up to the age of thirty-five we know him solely as a painter and as one of the greatest draughtsmen that have ever lived. It is often said that Leonardo drew so well because he knew about things ; it is truer to say that he knew about things because he drew so well. This at any rate is consistent with a chronological approach to the manuscripts. And here I offer a second clue to the study of Leonardo's mind. It should be studied chronologically. This method disposes of some of the difficulties which I have said that the notebooks might present. For example, the fact that so much is copied from other writers simply reflects Leonardo's powers of self-education. Brought up in the country, and destined at an early age to the craft of painting, he must have been taught in his childhood what used to be called "the three Rs" ; of which in Florence the last, arithmetic, was given particular importance. He would not have learnt Latin ; and in fact we know that he taught himself Latin in about the year 1494, and copied into two of his notebooks, those known as MS. H and the Trivulzian, the greater part of Niccolo Perotti's Latin Grammar and Luigi Pulci's Vocabulary. When we consider how few learned writings were, at that date, available in the vulgar tongue, we



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A Study of the Deluge

realize what a turning-point this was in his intellectual development.

The first of Leonardo's writings which can properly be called scientific are of a slightly earlier date—between 1485 and 1490—and, as might be expected, they are part of an attempt to give a scientific basis to the art of painting. In this Leonardo was following an established practice of the early Renaissance. Plato had established four liberal arts—arithmetic, geometry, astronomy, music—which were the basis of all true knowledge. This number was afterwards increased to seven by the addition of grammar, logic and rhetoric; and in the middle ages this list was the subject of various glosses and expansions. But none of these included painting among the liberal arts. This had much distressed the painters of the

Renaissance, partly from reasons of prestige, and partly because they were convinced by Plato's arguments, and thought that some mathematical or harmonic basis really was necessary if painting were to be a branch of true knowledge: hence the purely mathematical approach of early books on Art such as Alberti's *della Pittura*, and Piero della Francesca's *Prospettiva Pingendi*. Leonardo also wished to raise the status of painting from a manual to an intellectual art. A large part of his *Treatise on Painting* is devoted to this end, especially the comparison of the arts, the so-called *Paragone*; and it was therefore an historical necessity that his study of the science of painting should be built on mathematics. "Let no one who is not a mathematician read my works": this and similar warnings occur

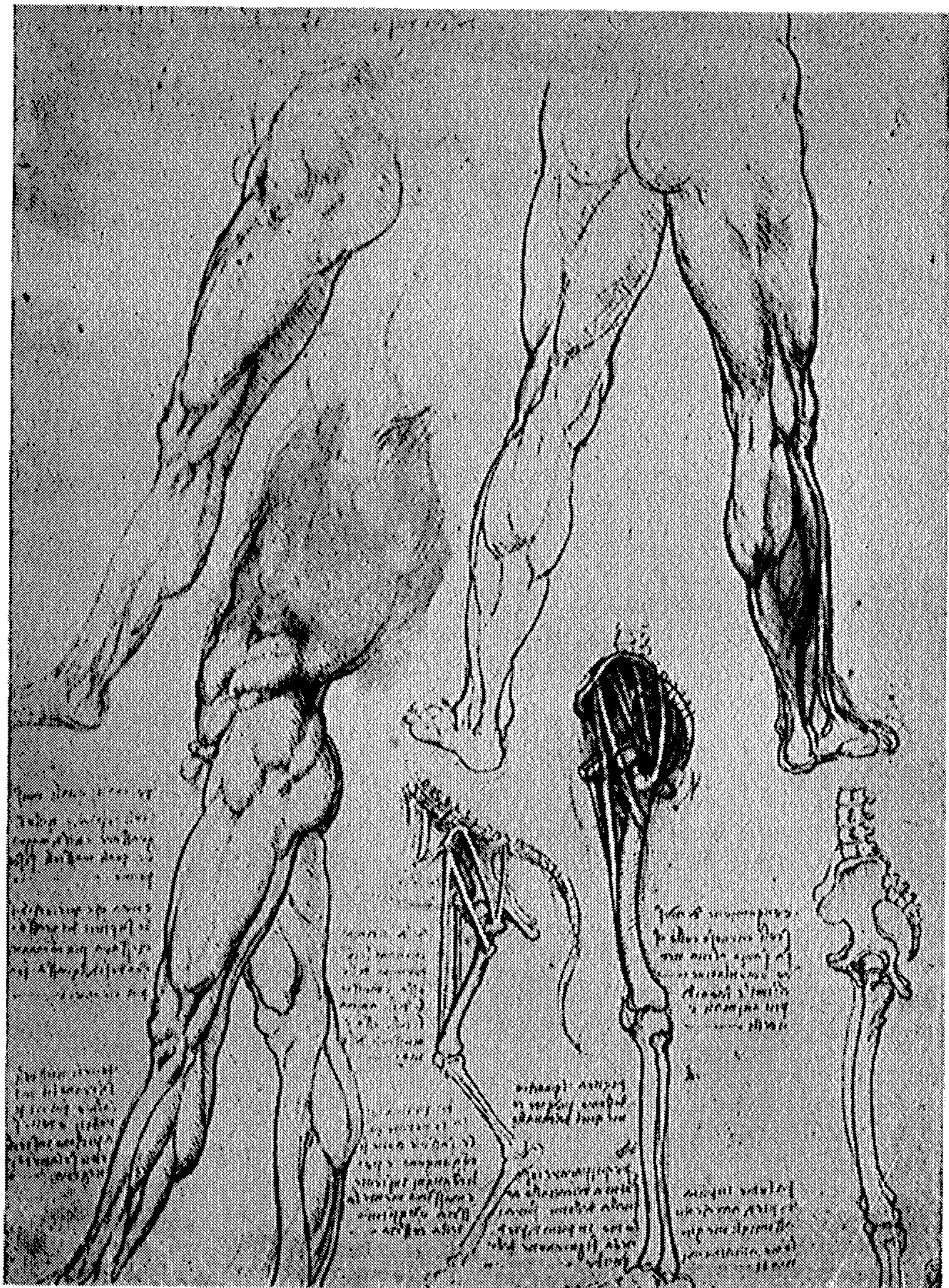
throughout the notebooks, and are borne out by the numerous diagrams in Leonardo's earliest dated manuscript, that known as MS. B in the library of the Institut de France. Most of these treat of light and shadow. He also wrote a treatise of perspective, now lost. We know of it from references in Vasari, and Benvenuto Cellini bought a copy while in the service of Francis I. The loss is most unfortunate because we can tell from Cellini's description and from some of Leonardo's notes in other manuscripts that he had greatly enlarged the theory of perspective. These matters are too technical to be of general interest, but I mention them in order to emphasize a point of great importance: that Leonardo began his study of phenomena with an all-controlling belief in mathematics. This was partly because mathematics were certain—"In them," he says, "one does not argue if twice three makes more or less than six: all argument is reduced to eternal science, and they can be enjoyed in a peace which the lying sciences of the mind cannot attain"—and partly because mathematics were the source of harmony. Leonardo, although usually considered an Aristotelian, accepted with eagerness the Platonic faith in proportion. In the *Treatise on Painting*, for example, he speaks of the senses being satisfied by a harmonic relationship of the parts which compose the whole; and in MS. K (49) he writes, "Proportion is not only to be found in number and measure, but also in sounds, weights, times and places, and in every power that exists." It is such a sentence as this which justifies the statement of Gabriel Séailles,⁴ in that admirable book from which M. Valéry drew so much of his material, that for Leonardo the universe was a mathematical reality overlaid by appearances.

But although Leonardo accepted for a time this framework of mathematical reality, he was not sufficiently platonic to believe that appearances were unreal. If challenged he might have said that their reality was complementary to that of mathematics. In fact his instinct as a painter, no less than his natural curiosity, led him to value appearances far more highly. I said just now, to the men of the Renaissance

⁴ Gabriel Séailles, *Léonard de Vinci, L'artiste et le savant*, Paris 1892.

painting was a branch of knowledge. Leonardo says, "If you despise painting, which is the sole means of reproducing all the known works of nature, you despise an invention which, with subtle and philosophic speculation, considers all the qualities of forms: seas, plants, animals, grasses, flowers, all of which are encircled in light and shadow." He goes farther and claims that by his creative power the mind of the painter is transformed into the likeness of the mind of God. And this is only achieved by intimate understanding of all that he creates. He must consider *all* the qualities of forms—animal, vegetable or mineral. And so Leonardo takes up the study of biology, botany and geology.

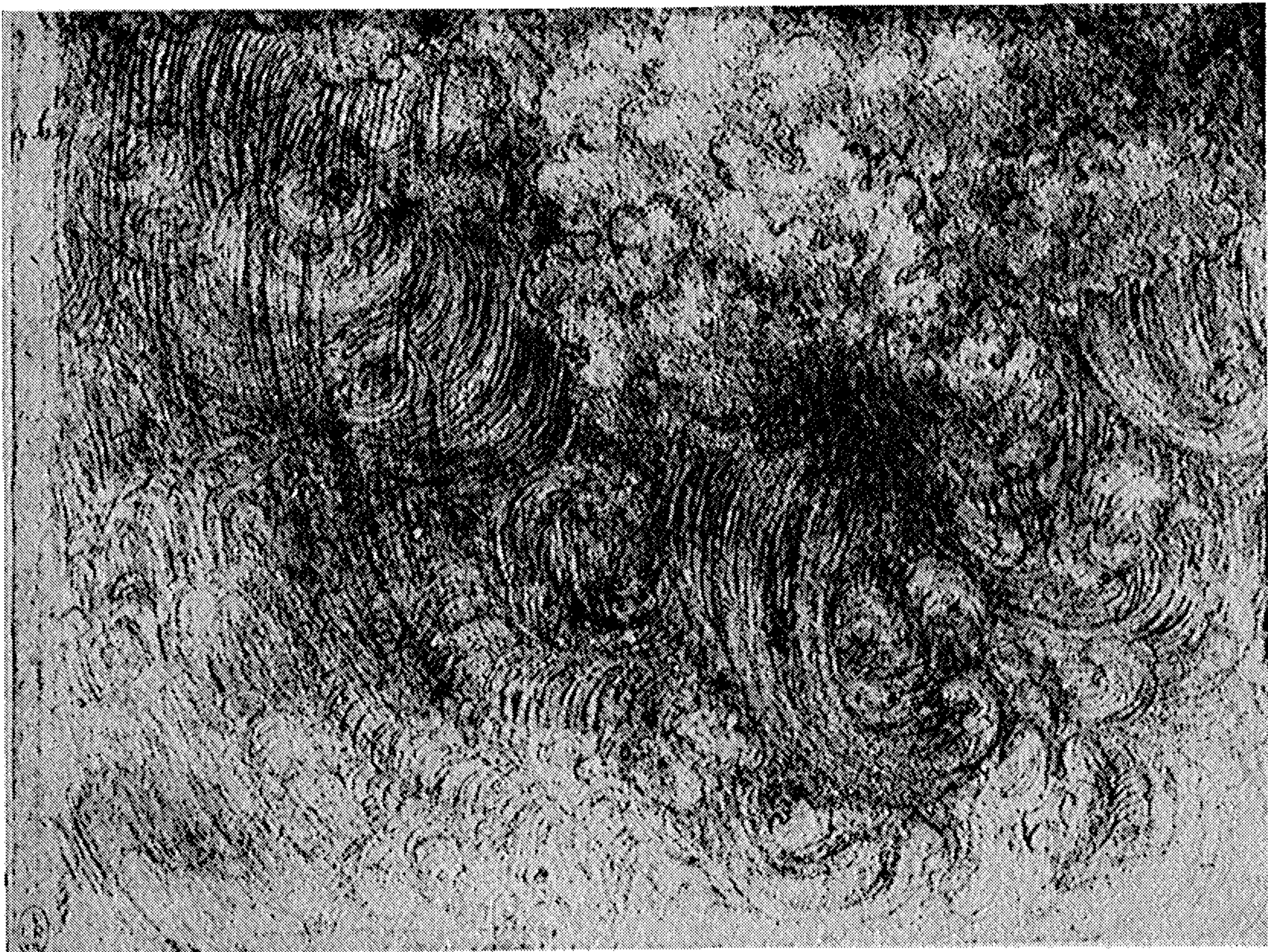
He begins with man. Anatomy had been studied by the Florentine artists since the early fifteenth century. Antonio Pollaiuolo, who had a great influence on the style of Leonardo's drawings, was certainly a skilled anatomist. But from the start Leonardo exceeds the demands of art-school anatomy. For example, his inquiring mind must investigate the inner structure of a skull. The drawings of a bisected skull in a sketchbook dated 1489, of the same period as the studies of light striking a sphere, are amongst the most delicate and perceptive he ever did. Ten years later he was studying anatomy as an end in itself, and by 1504 he was examining the problem of generation. It is the first example of a change from the mechanical to the organic which was to be the main direction of his mind during the next twelve years. At about the same date he begins to study comparative anatomy. In his pre-scientific period he had made some drawings of a bear, and after its death had dissected its feet, clearly with a view to comparison with the human foot: but there are no notes on the subject. In 1504 he investigates the subject far more thoroughly. On a sheet at Windsor which also contains a sketch for the *Battle of Anghiari*, he compares the legs of a horse and a man, a comparison which is carried farther in one of his pocket-books, MS. H. This method of comparison and analogy, which may properly be called scientific, was to be used more and more by Leonardo in his other investigations. I may add that Leonardo never entirely lost sight of his original aims in



Study of the Anatomy of Legs By gracious permission of H.M. the Queen

anatomy. He intended to write a systematic treatise on anatomy, and notes in 1510 that it will be finished in the Spring of that year. This note occurs in a MS. which was, perhaps, to form part of the work ; and both in pose and treatment of the muscles it anticipates the standard anatomical figures, the so-called *écorchés* which figured so prominently in

academies of art up to the present century. But the art-school anatomies in this book are done in an unusually dull and lifeless style, as if he were discharging a tiresome duty. There is far more interest in the almost contemporary drawings illustrating his notes on the vital human organs, the heart, lungs, etc. Here we are brought back to the curious limitation of



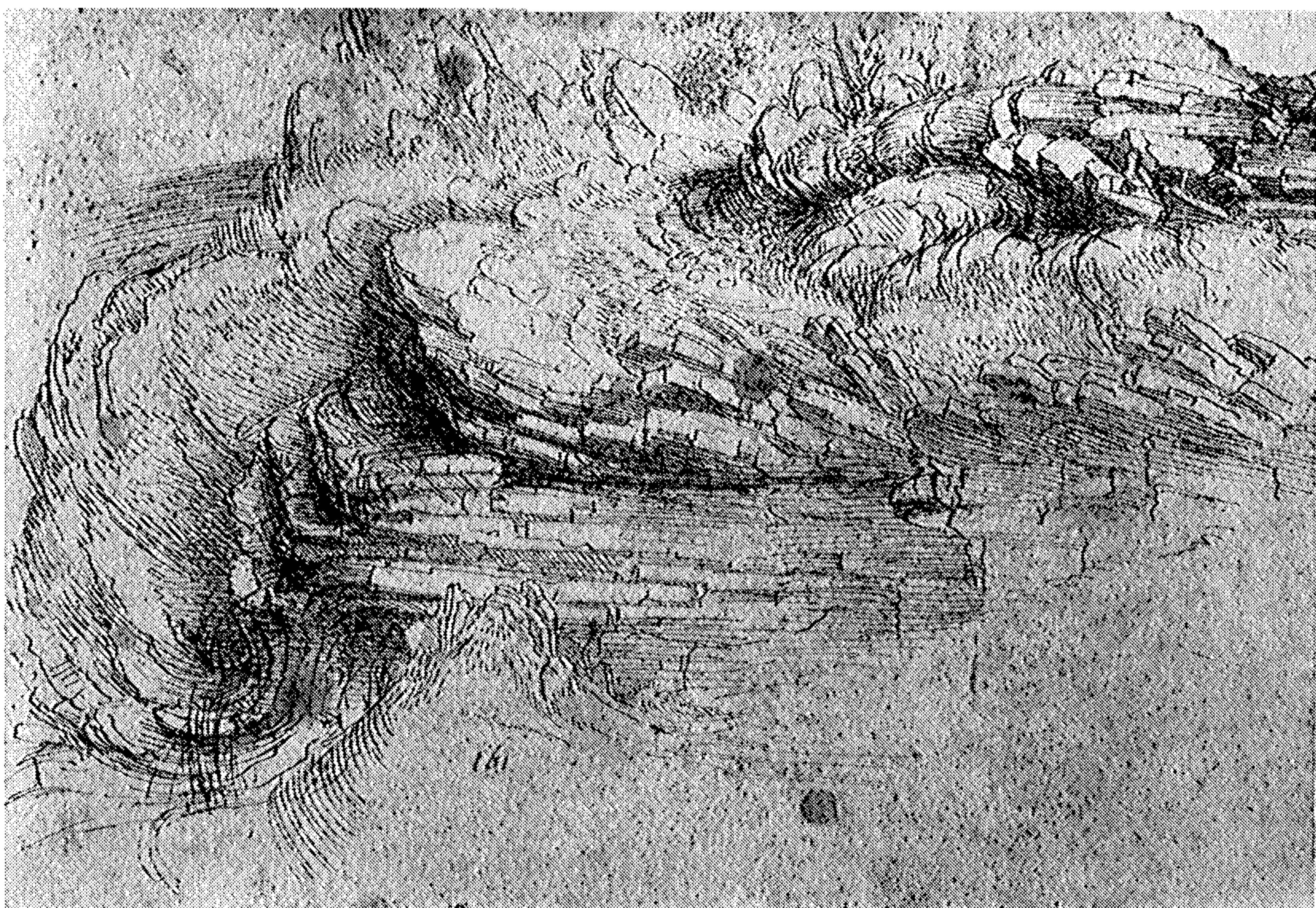
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Study of a Wave

Leonardo's mind which I mentioned earlier. Although these drawings seem to show that he had observed the circulation of the blood as a fact, he never states it as a principle. Still less does he propound a theory of evolution, although from his notes on comparative anatomy it seems to be in his mind. As his experience enlarged he became more and more opposed to general statements of any kind, and this dislike of formulation (if it was a conscious dislike, and not some curious incapacity) is alone responsible for the fact that Leonardo is not one of the central figures in the history of science.

So the progress from mechanism to organism begins with anatomy. But man is a part of nature, and Leonardo's keen sense of analogy suggested that a similar organization, with similar laws of growth, existed in the vegetable and even the mineral world. The old medieval

doctrine of the microcosm and macrocosm must be proved by observation. Once again he observes with the eye of an artist. His pocket-books are full of notes on the structure of trees and plants. Accompanying these sketches are clear-sighted observations of the colour of leaves, of reflected light and transparency. They might be the notes of an Impressionist and in fact are very similar to observations in the sketch-books of Constable. The same book, MS. G., contains notes on what Leonardo called *la prospettiva di colore*, the modification of colour by atmosphere, a subject which he also studied during his expeditions in the mountains. And there are notes on the colour of smoke and mist, which remind us of Goethe. Only his dislike of formulas prevented him from anticipating Goethe's theory of translucency. His interest in the play of light, in accordance with the



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Stratification of Rock

general drift of his mind, developed from state to motion. In contrast with the static diagrams of the 1480's later studies show him trying to analyse the sparkle of light on the waves. The drawings of plants done at the date of the *Leda*⁵ certainly had a dual intention. To some extent they were preparatory to the picture, to some extent accurate botanical studies complete with details of seed pods and notes of similar genus, etc. Or was this, after all, only one intention? Was this scientific knowledge of a seed pod necessary if the plants in the *Leda* were to have their full significance as symbols of vegetable vitality, of the unsubduable demand for rebirth. Leonardo's notes often indicate that his scientific observations continued to be linked with his intentions as a

⁵ Painted in Florence in about 1506; taken to Fontaine bleau and lost or destroyed. Known from copies, of which two are in the present exhibition at Burlington House, nos. 255 and 259.

painter, long after they seem to us to have diverged on their own.

Where botany is concerned it is hard to say that his researches carried his art any farther. The flowers in the *Vierge aux Rochers*⁶ are surely accurate enough for any painter, even for one who felt the need to know more than he showed. In geology, on the other hand, I believe that Leonardo's investigations resulted in a real advance, both artistically and scientifically. He had inherited the tradition of fantastic rocks dating back to Hellenistic painting, and since we look first at those objects in nature which have received the blessing of art, these were the subject of his first geological observations. The rocks in the *Vierge aux Rochers* show a little more knowledge than those of his contemporaries, but they are much less closely observed than the

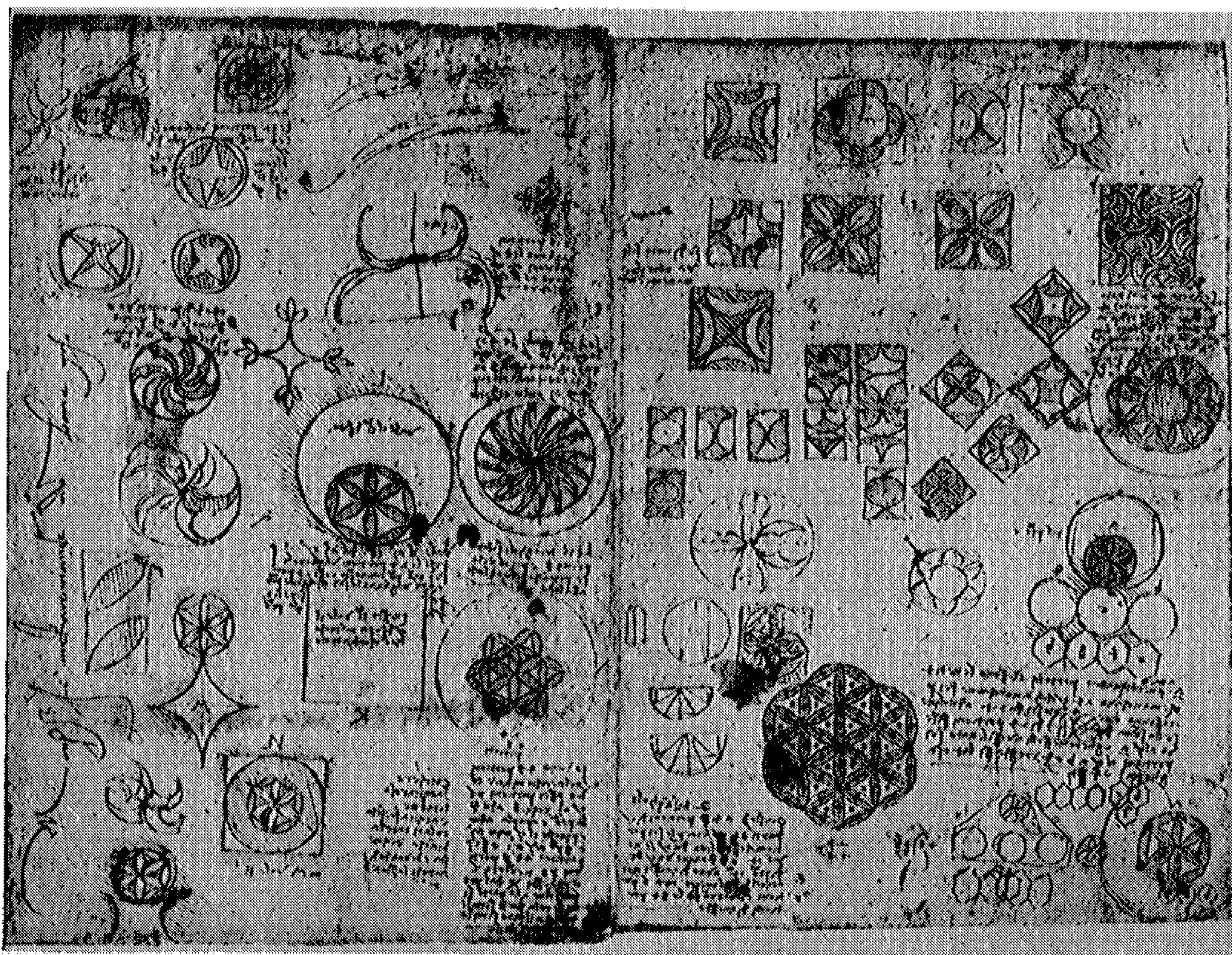
⁶ In the Louvre. Painted c. 1482.

flowers, where he had behind him the long tradition of Gothic naturalism. But during the 1490's, the great period of Leonardo's mental expansion, he begins to take a more scientific interest in landscape, and sees rock forms as part of the whole earth's structure. This is what he shows us in the beautiful drawing at Windsor of a storm breaking over the foothills of the Alps, which records an observation, but one chosen for its effect on the emotions. By very slight changes it could become the background of the *Mona Lisa*.

In the background of the *St. Anne* this balance between the scientific and the fantastic is developed. Leonardo has made more studies of rock formation, such as the one on page 309, and he has spent much time in the mountains, studying the bones of the earth with the same concentrated attention that he gave to the bones of man. And at this point he formed a concept which was to have a profound effect on his mind. It is hinted at in a passage in the manuscript known as the Leicester Codex, which contains, to my mind, the finest of all Leonardo's speculations. "Nothing originates," he says, "in a spot where there is no sentient, vegetable, and rational life; feathers grow upon birds and are changed every year; hairs grow upon animals and are changed every year. . . . The grass grows in the fields, and the leaves on the trees, and every year they are, in great part, renewed. So that we might say that the earth has a spirit of growth; that its flesh is the soil, its bones the arrangement and connection of the rocks of which the mountains are composed, its cartilage the tufa, and its blood the springs of water. The pool of blood which lies round the heart is the ocean, and its breathing, and the increase and decrease of the blood in the pulses, is represented in the earth by the flow and ebb of the sea." So the earth, like man, and plants, and light—the solid earth—is in a state of continual change. Corroborating and extending this concept were the shells and fossils which Leonardo had observed when investigating the structure of mountains. How had they got there? The answers to this question, which occupy many pages of the Leicester Codex, show Leonardo's mental processes at their best. We see the value of his tiresome obstinacy, his determination never to

take anything on trust. He will not for a moment admit the idea of special creation, and he advances decisive arguments against the accepted idea, that shells had been carried to the tops of mountains by the Flood. Readers of Gosse's *Father and Son* will recognize that in this he was in advance of an eminent naturalist of the nineteenth century. In the end he concludes that the whole earth is constantly being worn away, and remade by the action of water. What blood is to the body, water is to the earth, *l'acqua e il vetturale della natura*. He had returned to the conclusion of Heraclitus, that everything is in a state of flux. But this is no longer an inspired guess (for such I take it are most of the generalizations of pre-Socratic philosophy), but the result of a thousand painstaking observations. The inescapable conclusion of Leonardo Vinci, *dissciepolo della sperientia*.

These discoveries were made about the year 1510 when Leonardo was living in Milan. It was a period of intense activity, when, beside the scientific researches I have just alluded to, he was engaged on a number of works of art, some official, like the monument to Marshal Trivulzio, some intensely personal, like the *Virgin and St. Anne* and the *St. John* in the Louvre. Such activity did not admit of hesitation or distraction. The urge to discover and record the facts had lost none of its force. He was still driven on to clothe with flesh the mathematical and harmonic structure in which, twenty years earlier, he had so firmly believed. But in 1512 outside events disturbed him. An alliance of Spaniards, Papal Mercenaries and Venetians drove the French out of Milan, and the city, which had been gradually losing its veneer of civilization, became completely disorganized. Leonardo retired to the villa of his friend, Francesco Melzi, and a year later, like every other artist in Italy, made his way to the Rome of Leo X. The Pope gave him rooms in the Belvedere of the Vatican, and treated him with honour. But he could not settle to work. Vasari records the Pope's exclamation of despair, "*Oime, costui non e per far nulla.*" "Alas, this fellow will never do anything because he begins by thinking of the end of a work before the beginning." Vasari also recalls scientific jokes with which he occupied his



From the Codice Atlantico, Ambrosian Library, Milan

Geometrical Games

time—animals of paste which flew, and a lizard dressed up to look like a dragon ; and this statement is borne out by many sheets of scribbles dating from this epoch, containing puzzles and similar trifling. We are told that he executed for Giuliano de' Medici a book of geometrical games, and may presume that it contained figures similar to those on this page, which have about as much to do with geometry as a crossword puzzle has to do with literature. What had happened ? Partly, no doubt, the new atmosphere did not suit him. The solitary old exquisite who had lived for so long according to his fancy, remote from the world, found himself quartered among half the leading artists of Italy, crowding, criticizing, jockeying for position. But I think that something far more fundamental had taken place. To put it crudely,

he had got out of his depth. The facts which he had collected to clothe his mathematical framework had grown too numerous and too complex ; and they had led him to a conclusion for which his mathematics were inadequate : that the basis of all phenomena was change and movement. No wonder he despaired of ever putting his researches in order. From the Uffizi *Adoration* onwards he had shown a dislike of finishing things. And now the knowledge that he could never put the work of his lifetime into a final form gave him an agonizing sense of frustration. *Di mi se mai fu fatta alcuna cosa*—tell me if anything was ever done. These were the first words to flow from his pen at any vacant moment. *Di mi se mai, di mi se mai*, again and again, dozens of times, we find it on sheets of draw-



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Old Man meditating, and studies of moving Water

ings, among scribbles or mathematical jottings, or beside the most painstaking calculations. It is the *leit motif* of his old age. A drawing at Windsor (above), which dates from these years, seems to symbolize his state of mind. It shows an old bearded man seated in profile, his head on his hand, gazing into the distance, with an air of profound melancholy. His nut-cracker nose and sharply turned down mouth remind us of the old men in Leonardo's unconscious scribbles, but his curling beard and large deep-set eye recall the likenesses of Leonardo himself. Even if this is not strictly a self-portrait we may call it a self-caricature, using the word to mean a simplified expression of essential character. Opposite him on the sheet are studies of swirling water and a note comparing its movement to that of plaited hair ; and although these studies were not

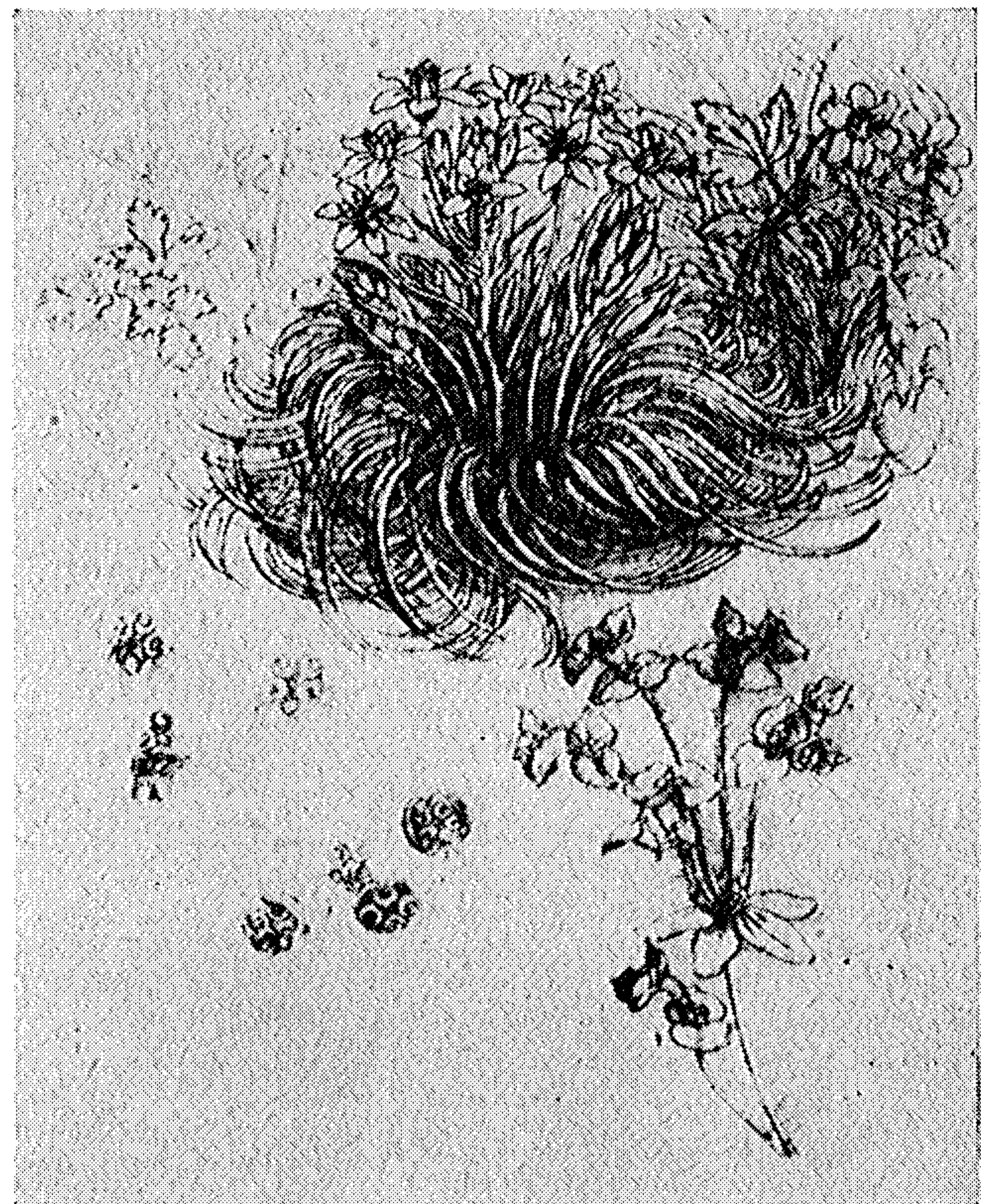
intended to have any connection with the old man, for the sheet was originally folded over, they are like the projection of his thoughts.

For of all Leonardo's interests the most continuous and obsessive was the movement of water. At various times in his life he had been able to turn this obsession to semi-practical ends by applying himself to problems of canalization and irrigation. But the quantity of his notes on the subject—it forms one of the largest and most disheartening sections of his written work—and the quality of his drawings show a passion with no relation to practical life. Some of his studies of swirling water are amongst the most direct expressions of his sense of form, springing from the same mysterious source as his love of knots and tendrils. A sheet at Windsor shows water taking the form of both hair and flowers, racing

along in twisted strands, and pouring from a sluice so that it makes dozens of little whirlpools, like a cluster of ferns with long curling tendrils. His superhuman quickness of eye has allowed him to delineate forms of movement since confirmed by spark photography, and we must take these drawings of water as genuinely scientific. But as he gazed half-hypnotized at the ruthless continuum of watery movement, Leonardo began to transpose his observations into the realm of the imagination, and to associate them with an idea of cataclysmic destruction which had always haunted him. The result is a series of drawings at Windsor which, even now, are less famous than they deserve to be.

Each epoch of taste finds in a great artist's output certain symbolic works, through which, for the time, he is popularly known. Leonardo, in the late eighteenth century, was known through his caricatures and grotesques ; in the late nineteenth century through the *Mona Lisa*'s smile. To the present age those visions of catastrophe, in which a huge cloud fills the sky like a menacing flower, and sends down ribbons of destruction on to the peaceful landscape, may seem the most poignant and relevant of all his works (page 305). In Leonardo's conscious mind they were probably connected with certain writings and sermons foretelling the end of the world, which were common in the years before the Reformation. But to anyone who has followed the development of his spirit they have a deeper and more personal significance. Leonardo has taken that branch of scientific investigation to which he had given the most concentrated thought and in which his eye had been most continuously engaged, and has used it, as Michelangelo came to use his knowledge of the human body, to express his sense of tragedy. And what was this tragedy ? It was the failure of human knowledge in the face of the forces of nature ; and for Leonardo the symbol of this failure was precisely that flux, that continuum to which all his researches had led him.

We can see now that this failure was relative. Leonardo had gone too far ahead of his times. He had made a discovery which should have been buried or put back on the shelves. He had been the disciple of experience in an age



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Study of Star of Bethlehem

before experience could be absorbed. It was possible *in his art* to anticipate the theories and spatial movements of the next 100 years. But it was not possible *in his thought* to do the work which was to occupy the philosophical, mathematical and scientific genius of the seventeenth century, and was to culminate in Newton's discovery of the calculus. Here, once more, was a framework into which Leonardo's observations could have fitted. But in 1516, when he accepted Francis I's invitation to settle in France, these triumphs of the human mind were far out of sight ; and Leonardo was glad to retire like an old magician, into a kind of hermetical seclusion.